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Attorney Docket No.	970118	Total Pages	2

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

First Named Inventor or Application Identifier	
Thomas E. Kaib	
Express Mail Label No.	EM203363755US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. [X] Fee Transmittal Form *(Submit an original, and a duplicate for fee processing)*

2. [X] Specification *[Total Pages* 42 *]* *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure

3. [X] Drawing(s) *(35 USC 113)* *[Total Sheets* 5 *]*

4. Oath or Declaration *[Total Pages* _ *]*
   a. [ ] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional with Box 17 completed)* *[Note Box 5 below]*
      i. [ ] **DELETION OF INVENTOR(S)** Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).

5. [ ] Incorporation By Reference *(useable if Box 4b is checked)* The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. [ ] Microfiche Computer Program *(Appendix)*

7. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. [ ] Assignment Papers (cover sheet & document(s))
9. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
10. [ ] English Translation Document *(if applicable)*
11. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
12. [ ] Preliminary Amendment
13. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
14. [X] Small Entity Statement(s) [ ] Statement filed in prior application, Status still proper and desired
15. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. [ ] Other: ....
   ....
   ....

17. If a **CONTINUING APPLICATION**, check appropriate box and supply the requisite information:
[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: _____ / _____

18. CORRESPONDENCE ADDRESS

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TITLE

BATTERY MANAGEMENT APPARATUS FOR PORTABLE ELECTRONIC DEVICES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to portable electronic devices which utilize batteries. More particularly, the present invention relates to portable medical devices. Still more particularly, the present invention relates to methods and apparatus for the maintenance and management of the batteries of such portable medical devices.

2. Description of the Prior Art

Battery management is a concern in any portable electronic device, but is a primary concern in portable medical devices. The need for more comprehensive battery maintenance in portable and implantable medical devices has been noted, for example, in U.S. Patent No. 4,080,558 to Sullivan, U.S. Patent No. 5,411,537 to Munshi, et. al., U.S. Patent No. 5,483,165 to Cameron, et. al., and U.S. Patent No. 5,470,343 to Fincke, et. al.

A defibrillator is a device capable of delivering a preset amount of electrical energy to a patient's heart for the purpose of terminating an arrhythmia. For portable defibrillators, batteries are used to provide the electrical energy delivered. Historically, portable defibrillator maintenance has been problematic due to insufficient means to ensure comprehensive

management of the batteries. As portable medical devices are intended for relatively long-term monitoring and, in the case of portable defibrillators, intended for therapeutic shock delivery for patients at risk from sudden cardiac death due to tachyarrhythmias, a comprehensive battery management program is essential.

Historically portable defibrillator design has been concerned with ensuring that the devices function properly when needed. Problems may arise if the batteries of the defibrillators are at less than full capacity or are worn out or are accidentally taken off their chargers so that the batteries are nonfunctional.

Therefore, there is a need in the portable electronic device industry, and, in particular, in the portable medical electronic device industry to implement a comprehensive way of informing the patient, as precisely as possible, of the status of that patient's device, and particularly the status of the device battery. This status should include not only the current conditions of the device battery but also other information, such as an indication of how much time remained in which the device would be operable.

SUMMARY OF THE INVENTION

The present invention is preferably utilized in connection with a patient-worn energy delivery system for imparting electrical therapy to the body of a patient responsive to an occurrence of a treatable condition. The present invention is designed to constantly monitor and comprehensively inform the patient of the condition of the device, and particularly the condition of the device battery.

The system includes a monitor-defibrillator worn by the patient. The monitor-defibrillator monitors the patient's ECG to detect life threatening arrhythmias and delivers a

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cardioverting or defibrillating shock if needed. The monitor-defibrillator records system operational information and ECG signal data. Periodically the patient is required to off-load this information to a patient base station. This is accomplished when the monitor-defibrillator is connected to a patient base station at the time battery charging is initiated. Thus, the patient base station is coupled with the monitor-defibrillator for periodic battery charging, device maintenance and the offloading of data. When a monitor-defibrillator is inserted into the monitor interface connector, the patient base station retrieves battery status from the monitor. The patient base station analyzes this information and may schedule maintenance operations or patient notifications if certain conditions are met.

The primary functions performed by the patient base station are providing data communication interfaces to the various components of the system, battery pack charging and maintenance, monitor-defibrillator maintenance, monitor-defibrillator data retrieval and storage, facilitating monitor-defibrillator initialization via the physician programming console and providing visual and audible feedback for patient interactions.

The patient base station provides means to simulate the operation of various monitor-defibrillator and electrode harness hardware functions. These enable the patient base station to verify that the monitor-defibrillator and the electrode harness hardware is functioning properly.

A physician programming console is also utilized, which is an IBM PC-AT compatible computer. The physician programming console facilitates programming of the patient base station and the monitor-defibrillator. Also included is an electrode harness, worn by the patient on the chest, which contains electrodes for sensing ECG signals from the heart and large surface area electrodes for delivering therapy pulses to the heart in the event of the occurrence of a treatable arrhythmia.

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The monitor-defibrillator indicates the future time or activity level remaining at which the device could operate. The apparatus considers the rates of discharge and the rates of use and the amount of energy taken out of the battery. The device also monitors the number of charge cycles on the battery, the date when the battery was installed and other pertinent information such as battery pack expiration parameters.

The monitor-defibrillator itself includes circuitry to monitor the capacity of the battery. Thus, if the monitor-defibrillator undergoes some kind of abnormality, for example, some component begins drawing more current than the normal average current of the device, the circuit will detect the abnormality and the current will trip a comparator. The comparator alerts the computer and the remaining run time of the battery pack will be adjusted accordingly and can be displayed to the patient.

The patient base station also periodically performs a capacity check on the monitor-defibrillator when the monitor-defibrillator is coupled to the patient base station during charging and maintenance operations. This is a more comprehensive check than the one performed internal to the monitor-defibrillator. The patient base station can discharge the battery fully, charge it up fully and then discharge the battery. The current that's being discharged is precise, thus, over a period of time the processor could calculate whether the actual capacity of the battery is meeting the specifications. Factors such as the amount of charge and the rate of discharge are considered.

Having the capability to perform the monitoring functions on the monitor-defibrillator rather than solely at some remote base station is beneficial because the battery is necessarily contained in the monitor-defibrillator or attached to it via an electrical connector. Thus, if the

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patient has traveled away from the base station, that patient would have to return to the base

station to be certain that sufficient capacity remained in the battery.

The objects and advantages of the invention will become apparent from the following

description of certain present preferred embodiments taken in conjunction with the attached

drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a patient base station block diagram showing the patient base station,

physician's programming console and the monitor-defibrillator connected to either the patient

base station or the electrode harness.

Figure 2 is a block diagram showing the patient base station computer, real-time clock,

counter timer, analog/digital converter and backup battery, and monitor-defibrillator battery

connection.

Figure 3 is a block diagram for the battery load test function.

Figure 4 is a diagrammatic perspective view of the monitor-defibrillator and patient base

station.

Figure 5 is a block diagram for the patient base station patient interface module.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An apparatus is provided for monitoring and supporting the monitor-defibrillator

electronics and the rechargeable battery pack provided therein. The system 10 of the present

invention is shown schematically in Figure 1. As can be seen from Figure 1, the present system

10 involves a number of interrelated components. A monitor-defibrillator 12 is included which

is operatively connectable via an interface module 26, to either a patient base station 30 or an electrode harness 66 having two groups of electrodes 14, 16. A group of delivering electrodes 14 is provided for delivering a cardioverting or defibrillating shock when necessary to a patient. Another group of electrodes 16 performs sensing operations in which the physiological condition of a patient may be monitored. The delivering electrodes 14 are operatively connected to a converter-defibrillator 19 located within the monitor-defibrillator 12. The electrode harness 66 also includes a patient display 24 with the capability of displaying visual messages, enunciating audio messages and activating audio alarms. The patient display 24 also includes various buttons for providing the patient with a means of input to the device. The operation of the electrode harness/monitor-defibrillator are more particularly described in co-pending application Serial No. 08/651,274, assigned to the present assignee and hereby incorporated by reference herein.

The battery pack 18 is responsible for providing the necessary power to operate the converter-defibrillator circuitry for delivering the cardioverting or defibrillating shock. Therefore, it is important that the energy capacity of battery 18 be ensured. The monitor-defibrillator 12 preferably utilizes a high-energy-density nickel-cadmium battery. Preferably, the battery is comprised of five 1.2 volt cells connected in series to yield six volts.

The monitor-defibrillator 12 also includes battery control circuitry 20 which can activate the battery 18 to deliver its charge to the converter-defibrillator 19 and subsequently to the delivery electrodes 14 when necessary. The battery control circuitry 20 is responsive to certain data conditions of the patient. For this reason, the battery control 20 is operatively connected to data storage/processor 22, also located within the monitor-defibrillator 12. The data storage/processor 22 receives data from the sensing electrodes 16. The data storage/processor 22 in the monitor-defibrillator preferably utilizes non-volatile memory. The data storage/processor

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22 stores programmable system operational parameters, system operating status information, digitized ECG episodes and the results of hardware diagnostic tests. This data, through subsequent analysis, provides the means to allow reconstruction of ECG events and analysis of device performance.

The monitor-defibrillator 12 is able to perform various system and battery checks. Energy usage of the monitor-defibrillator 12 is monitored in real time to determine the useful energy remaining of the battery 18 per charge. The patient display 24 located on the electrode harness 66 indicates the operating time remaining for the battery 18. The patient may access this function at any time by pressing a button on the patient display 24. The run-time parameter is available to an external host via the communications interface located in the interface module 26. A low battery condition as determined by the monitor-defibrillator 12 is recorded in non-volatile memory of the data storage/processor 22. The patient is also alerted to a low battery condition by the patient display 24.

The monitor-defibrillator 12 monitors the battery current consumption and, if required, makes an appropriate adjustment to the battery run-time parameter based on sampling the real-time monitor-defibrillator current consumption. The current is monitored by an analog circuit in the monitor-defibrillator 12 and is input into a comparator at a trip level of current. The voltage is monitored but is not sent to the comparator. The trip level is a level of current that is based on a precalculated worst case (i.e., maximum) average current developed for the device. For the particular hardware used with the present invention, the amount of typical maximum run current (i.e., the trip level current) is 74 milliamperes. If the measured current exceeds the trip level, the comparator trips and the analog to digital converter in the data storage/processor 22 is commanded to read the analog representation of the current that is being drawn by the monitor-

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defibrillator 12. The monitor-defibrillator 12 measures the time period of excessive current draw and the amount of current above the trip level. Based on the measured readings, time is deducted from the battery runtime parameter by the monitor-defibrillator. The updated runtime remaining may be accessed by the patient at any time, as discussed above.

As long as the actual, measured current of the monitor-defibrillator 12 is less than the trip level current, the data storage/processor 22 presumes that the actual current is the same as the trip current when deducting time from the battery runtime parameter. Thus, although the typical maximum run current is provided as 74 mils, the battery 18 is nearly always providing a current below 74 milliamps.

The patient has the capability to access buttons on the patient display 24 that when activated will cause the remaining run time to be indicated. If a patient is very active so as to cause one of the sensing electrodes 16 to have fallen off or otherwise become disconnected from the patient, an alarm is sounded. The activation of this alarm also utilizes energy which will be subtracted from the run time.

The current measuring capability of the monitor-defibrillator 12 does not include current drawn by the converter-defibrillator 19. The monitor-defibrillator 12 tracks the periods when the converter-defibrillator 19 is actively drawing current from the battery 18 and makes adjustments to the battery run time to compensate for the energy loss.

The monitor-defibrillator 12 also makes adjustments for depletion of battery 18 capacity during periods when the device is not being used. When not in use (such as when stored on a shelf or taken by the patient on a day's outing as a spare device) the monitor-defibrillator 12 will automatically power itself up at specified intervals and make adjustments to the battery run time

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to compensate for energy losses due to self-discharge of the battery and current draw of monitor-defibrillator 12 components when powered down.

The monitor-defibrillator 12 will utilize measures intended to reduce depletion of battery 18 capacity in order to maximize available energy if a treatment pulse is required. The monitor-defibrillator 12 will be optimized to execute its monitoring functions as rapidly as possible and then enter a low power operating mode until the monitoring functions must again be executed. The monitor-defibrillator can be kept in a low power operating mode when not performing necessary system operating functions. Additionally, when possible, high current devices will be powered down after completing their required tasks. An example would be the analog to digital converter. By scheduling analog to digital conversion readings at the beginning of monitoring functions, the analog to digital converter can be powered down sooner than if analog to digital readings are interspersed throughout the monitoring functions.

If the run time parameter indicates that the depletion of battery 18 capacity has reached the level at which the battery 18 should be recharged utilizing the patient base station 30, then the patient display 24 will provide notification. The notification will consist of visual and/or audio indicators. The notification will require acknowledgment by the patient before it will be discontinued. The notification will be repeated at predetermined intervals, for example, every 15 minutes, until the battery 18 is recharged by the patient base station 30. The monitor-defibrillator 12 can also determine the available device operating time (prior to recharging the battery), taking into account at least: (1) adjustments for abnormally high current draw of the device including adjustments for converter operation or operation of other high current draw devices as well as adjustments for excessive current draw from a defective component; (2) adjustments for normal current draw during an elapsed time period; (3) adjustments for device

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fault conditions such as failure of a battery load test or a problem with operation of the converter; and (4) adjustments for depletion of battery capacity during periods of non-use. The patient display 24 or alarms can be used to notify the patient of the available device operating time.

The monitor-defibrillator 12 will also utilize an analog to digital converter located in the data storage/processor 22 to supervise the battery 18 voltage during operation of the converter-defibrillator 19. The converter-defibrillator 19 may be operated in either a fast charge mode or a slow charge mode. The fast charge mode minimizes the time to charge the converter-defibrillator 19 but at a maximized current draw from the battery 18. The slow charge mode minimizes the capacitor charging current but with an increased time to charge the converter-defibrillator 19. The converter-defibrillator 19 is normally operated in fast charge mode.

If the battery 18 voltage falls below a level at which the monitor-defibrillator 12 can reliably operate the converter-defibrillator 19, then the monitor-defibrillator 12 will switch the converter-defibrillator 19 to a slow charge mode. This will permit the battery 18 voltage level to recover to a level at which the monitor-defibrillator 12 can again reliably operate the converter-defibrillator 19. Use of the slow charge mode permits the converter to be operated and a therapy pulse delivered to the patient when the battery 18 capacity is low.

If during operation of the converter-defibrillator 19 in the slow charge mode the battery 18 voltage falls below a level at which the monitor-defibrillator 12 can reliably operate the converter-defibrillator 19, then the monitor-defibrillator 12 will deactivate the converter and evaluate the energy capability stored in the converter. If the energy stored in the converter is sufficient to deliver at least a minimal energy pulse, such as, for example, 30 joules, then the treatment cycle will continue with delivery of the available energy. If there is not enough energy stored in the converter to deliver a minimal energy pulse, then the converter will be discharged.

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In addition, notification will be given using the patient display 24 that the device is disabled and medical assistance should be provided to the patient.

If the monitor-defibrillator 12 determines that the battery 18 capacity has fallen below a level at which the system performance data is in danger of being corrupted then the monitor-defibrillator 12 will remove operating power. The removal of operating power will reserve the remaining battery 18 capacity for maintenance of the data storage/processor 22. The integrity of the data storage is essential to evaluating the proper operation of the device. Since this low level of battery 18 capacity is inadequate for reliable operation of the monitor-defibrillator, the best possible use of the remaining battery 18 capacity is to preserve the operational history of the device stored in the data storage/processor 22. When this state has been reached, the monitor-defibrillator will refuse to power up until connected to the patient base station 30. If required, the patient base station 30 will provide additional energy to the monitor-defibrillator 12 to insure proper functioning during this power up sequence. The patient base station will then retrieve the operational history from the monitor-defibrillator 12 and recharge the battery 18.

The analog to digital converter located in the data storage/processor 22 is powered up each interim cycle to sample the analog inputs. This interim cycle is preferably every 5 milliseconds, which generally corresponds to the ECG sampling rate. After sampling the analog inputs, the analog to digital converter is powered down to conserve battery power. There are entire portions of the monitor-defibrillator 12 that periodically go into a low current sleep mode.

On a routine basis the patient is required to couple the monitor-defibrillator 12 with the patient base station 30 (see Figure 4). When the monitor-defibrillator 12 is removed from the electrode harness 66 and inserted in the receptacle 31 of the patient base station, connection is made between the monitor-defibrillator interface 26 and a monitor-defibrillator interface 32

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located within the patient base station 30. The patient base station monitor-defibrillator interface 32 is thus operatively connected to the data storage/processor 22 of the monitor-defibrillator 12. In this way, the monitor-defibrillator interface 32 can download information from the memory of the data storage/processor circuitry 22; i.e., information, that was received from both the sensing electrodes 16 regarding the patient's physiological data, and also from the battery control circuitry 20 regarding the operating history of the monitor-defibrillator 12.

The monitor-defibrillator interface 32 of the patient base station 30 is also operatively connected to the battery 18. In this way, the patient base station 30 can perform comprehensive tests as to the operating parameters of the battery 18. Further, charging of the battery 18 can also be performed through the monitor-defibrillator interface 32. The battery 18 of each monitor-defibrillator 12 requires periodic charging. Thus, monitor-defibrillators 12 that are not in use are to be stored on a patient base station charging port (i.e., coupled to the monitor-defibrillator interface 32), where they undergo charging and maintenance operations. The patient base station 30 provides battery status information to the patient by way of a visual display including indicator lights as well as by audio alarms provided by the patient interface 46.

The power required to charge the battery 18 of the monitor-defibrillator 12 is supplied by either an internal or an external power supply. As shown in Figure 1, an internal power supply 38 may be used which is operatively connected to the charger interface module 34. A switch mode type power supply 38 is preferred. However, a linear type power supply 38 could also be utilized. If a linear type power supply 38 is used, a heat sink and a fan would be needed in the patient base station 30. Use of a switch mode type power supply 38 would eliminate the fan, reduce the size of the heat sinks and would reduce the size of the system package and is thus preferred.

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The power supply 38 utilizes a power entry module 36. The power entry module 36 provides a standard IEC 320 type power entry connector. The power entry module 36 functions over a full range of standard household international voltages and frequencies. The power entry module 36 shall preferably use a standard international "1/0" icon for power status indication.

The monitor-defibrillator interface 32 is operatively connected to the charger interface module 34 within the patient base station 30. The charger interface module 34 provides a standard PC-AT compatible ISA type interface and provides all the necessary bus signals for computer control of the various charger interface module functions. In this way, data received by the monitor-defibrillator interface 32 from the data storage/processor 22 of the monitor-defibrillator 12 is provided to a computer 40. In this way, communication is then established for transfer of operational data to the patient base station mass data storage area 42. This data is a record of device performance and any ECG data that may have been stored within the monitor-defibrillator 12 during patient monitoring.

Thus, the patient base station initiates data retrieval operations from the monitor-defibrillator 12 if operational or ECG data is stored within the internal memory included in the data storage/processor 22 of the monitor-defibrillator 12. As part of normal maintenance of the monitor-defibrillator 12, this data is transferred to the patient base station 30 for long-term data storage 42. The patient base station 30 may store retrieved data on a removable floppy disk, removable or fixed hard disk or other removable media. In the preferred embodiment, the data is stored on a fixed hard disk. At the successful completion of data transfer, the computer 40 of the patient base station 30 issues a clear memory command via the monitor-defibrillator interface 32 to the monitor-defibrillator 12. This command erases the temporary memory in the data storage/processor 22 in the monitor-defibrillator 12. In the embodiment utilizing rotating media,

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the patient base station notifies the patient when the removable media requires replacement due to inadequate storage area remaining.

The computer 40 utilized by the patient base station 30 incorporates an imbedded, PC-AT-compatible computer architecture. The computer 40 preferably utilizes an Intel^{TM} 80x86 type central processing unit, with a performance no less than that of a 25 MHz 80386SX Intel^{TM} processor. The computer 40 preferably includes two standard PC-AT type serial ports. A modem interface port 44 should also be available for connecting the computer 40 to a telephone modem (not shown). The modem interface 44 is designed to interface to a telephone modem with no less than 14.4 kpbs data rate capability. The modem preferably interfaces to the single board computer 40 via one of its serial ports.

A physician's programming console ("PPC") interface 48 provides a communication link from the patient base station ("PBS") 30 to a physician's programming console 70. The physician's programming console interface 48 contains an ethernet communications module 52 for providing a standard 10 Mbps data link to the physician's programming console 70. This module 52 preferably interfaces to the single board computer 40 via an expansion bus 54. Data transfers between the patient base station 30 and the physician's programming console 70 are handled via the ethernet port 52. This allows the significant amount of data generated by the monitor-defibrillator 12 to be offloaded in a reasonable time at the physician's office during the patient's periodic visits. The external panel connection for the high speed physician's programming console 70 data link can use a standard BNC type female connector. A serial communications port 50 is also part of the physician programming console interface 48 and is provided for connection of the computer 40 to the physician's programming console 70. Data

transfer from the patient base station 30 to the physician's programming console 70 can also occur via high speed modem interface 44 from the patient's home.

The computer 40 is operatively connected to an ISA type expansion bus 54. The expansion bus 54 is designed to be capable of supporting up to four 16 bit expansion modules or cards. The computer 40 utilizes the expansion bus 54 to facilitate communications, control and status transfers to and from the charger interface module 34 and ethernet communication module 52 of the physicians programming console interface 48. The expansion bus 54 also provides power to the computer 40 and the ethernet communication module 52 from the charger interface module 34.

The operating system and applications software for the patient base station 30 may be stored on rotating media in the mass data storage area 42. However, the preferred embodiment embeds this software in non-volatile read only memory, such as EEPROM or FLASH memory. These embodiments allow the device to operate without need of rotating media. Additional non-volatile memory is provided to store certain manufacturing information and device-specific data. These memory locations are written to only during the initial manufacturing processes and are then write inhibited by hardware means. As shown in Figure 2, a real time clock may be implemented in conjunction with the computer 40 to maintain date and time of day information. The clock has backup power 62 provided to maintain operation if power is removed from the patient base station. A counter-timer 72 is provided to coordinate time critical operations. An analog to digital converter 64 is also provided.

The patient base station computer 40 controls battery charging, both rapid charging and float charging once the full charge point is reached. The computer 40 also controls discharging of the battery 18, as required. A battery capacity test is periodically performed to verify the

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stored energy capacity of the monitor-defibrillator battery pack 18. The system processor 40 controls all battery capacity measurement operations by discharging the battery 18 to a defined starting level, rapid-charging the battery 18 to full potential, implementing a timed discharge cycle to deplete the battery 18 and calculating the actual energy capacity. This process can determine if a bad cell is present in the battery pack, or the measured battery capacity is less than a defined acceptable limit.

The patient interface module 46, as shown in Figure 5, can have a visual display 47, battery status LED indicators 51, acknowledge push button 57 and ambient light sensor 49. The patient interface module 46 can be operatively associated with the charger interface module 34 and the analog to digital converter 64. The analog to digital converter 64 with an analog multiplexer is preferably provided within the patient base station 30. This analog to digital converter 64 allows the single board computer 40 (Figure 1) to monitor the charging current of the charger/discharger 34, discharging current of the charger/discharger 34, the battery voltage present at the monitor-defibrillator interface 32, the ambient light sensor 49 of the patient interface module 46 and the ambient temperature within the patient base station 30 enclosure via a temperature sensor 55 (shown in Figure 2).

Referring again to Figure 1, the patient interface 46 in the patient base station 30 indicates the status of the monitor-defibrillator battery 18 during the battery capacity test cycle. The patient interface 46 preferably incorporates a front panel mounted vacuum fluorescent (VF) type display 47 (shown in Figure 4). This display 47 may be a character type with standard 5mm, 5x7 dot characters. The PBS display 47 is preferably arranged in one of the following configurations: a 2 line by 40 character or a 4 line by 20 character. The PBS display 47 is controlled by the single board computer 40 via the charger interface module 34 through a parallel data interface.

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As an alternative, a graphics type LCD may be used for the PBS display 47. If an LCD display

is used, the patient base station may include an ambient light sensor 49 to control the LCD

backlight for improved readability.

In addition, the patient base station 30 tracks battery 18 usage and notifies the patient

when replacement of the battery 18 is required. If the battery 18 expiration parameters have been

exceeded (the expiration date or the number of charge cycles), the battery 18 can still be used by

the monitor-defibrillator 12, but the patient will be notified to replace the monitor-defibrillator 12

as soon as possible. The number of charging cycles performed on the battery 18 is recorded in

the monitor-defibrillator memory of the data storage/processor 22. Also, the date the battery 18

was installed in the monitor-defibrillator 12, the type of cell used in the battery 18, and the

expiration date of the battery 18 as well as any other pertinent information is stored in monitor-

defibrillator data storage/processor 22.

The communications interface created when the patient base station 30 and attached

monitor-defibrillator 12 is connected to the physician's programming console 70 is utilized

during the initial configuration programming of the monitor-defibrillator 12. Preferably, the

following information is configured: name, address, telephone number, hospital, attending

physician, medications; monitor-defibrillator detection and treatment parameters such as heart

rate threshold or rate cutoff, defibrillation energy to be delivered in therapy pulses; and monitor-

defibrillator manufacturing data such as device serial numbers, monitor-defibrillator battery pack

and expiration date, electrode harness(s) and expiration date(s).

A data communications protocol facilitates the transfer of digital information between the

patient base station 30 and the physician's programming console 70. This protocol consists of

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transferring data in blocks or frames. To ensure the integrity of transmitted and received data, the protocol implements error checking techniques.

The patient base station 30 to physician's programming console 70 communications protocol consists of transferring data in frames. Communication frames are transferred via the serial communication port 50. Serial communication port 50 hardware control lines are utilized to provide handshaking between the patient base station 30 and the physician's programming console 70 that will delimit the frame boundaries. Each communication cycle consists of a command frame sent from the physician's programming console 70 to the patient base station 30, followed by a response frame sent from the patient base station 30 to the physician's programming console 70. Each command frame will contain a command code followed by any relevant data, followed by an error checking code such as a CRC code.

If the command is successfully processed by the patient base station 30, the patient base station 30 will return a response frame that contains an ACK code, followed by the original received command code, followed by any relevant data, followed by an error checking code such as a CRC code.

If the command is not successfully processed by the patient base station 30, the patient base station 30 will return a response frame that contains a NAK code, followed by the original received command code, followed by any relevant data, followed by an error checking code such as a CRC code.

If a command frame is received by the patient base station 30 that contains an invalid error checking code, the patient base station 30 will ignore the communication frame. The physician's programming console 70 will be responsible for monitoring the patient base station

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30 response. If the patient base station 30 does not respond to a command frame the physician's programming console 70 can elect to resend the frame.

If a response frame is received by the physician's programming console 70 that contains an invalid error checking code, the physician's programming console 70 can elect to resend the frame.

Another data communications protocol facilitates the transfer of digital information between the monitor-defibrillator 12 and the patient base station 30. The protocol consists of transferring data in blocks or frames.

The patient base station ("PBS") 30 to monitor- defibrillator ("M-D") 12 communications protocol consists of transferring data in frames. Communication frames are transferred via the PBS/M-D interface 32. PBS/M-D interface 32 hardware control lines are utilized to provide handshaking between the patient base station 30 and the monitor-defibrillator 12 that will delimit communication frame boundaries. Each communication cycle consists of a command frame sent from the patient base station 30 to the monitor-defibrillator 12, followed by a response frame sent from the monitor-defibrillator 12 to the patient base station 30. Each command frame will contain a command code followed by any relevant data, followed by an error checking code such as a CRC code.

If the command is successfully processed by the monitor-defibrillator 12, the monitor-defibrillator 12 will return a response frame that contains an ACK code, followed by the original received command code, followed by any relevant data, followed by an error checking code such as a CRC code.

If the command is not successfully processed by the monitor-defibrillator 12, the monitor-defibrillator 12 will return a response frame that contains a NAK code, followed by the

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original received command code, followed by any relevant data, followed by an error checking

code such as a CRC code. The patient base station 30 will determine and execute a response

appropriate for the failed monitor-defibrillator 12 command process.

If a command frame is received by the monitor-defibrillator 12 that contains an invalid

error checking code, the monitor-defibrillator 12 will return a response frame that contains a code

indicating that the command was not properly received and should be resent. The patient base

station 30 can elect to resend the command frame.

If a response frame is received by the patient base station 30 that contains an invalid error

checking code, the patient base station 30 can elect to resend the frame or initiate monitor-

defibrillator 12 fault condition processing.

The patient base station 30 offers a collection of commands that the physician's

programming console 70 can utilize during communications with the patient base station 30.

The command set provides a means to initiate various patient base station 30 and monitor-

defibrillator 12 diagnostic, configuration, and data retrieval procedures.

The physician's programming console 70 can gain access to various monitor-defibrillator

12 information and operational features by issuing commands to the patient base station 30 via

the serial communications port 50. Upon receipt of these commands, the patient base station 30

will issue the appropriate commands to the monitor-defibrillator 12 via the PBS/ M-D interface

32, that will carry out the desired operation. The patient base station 30 will return to the

physician's programming console 70 the monitor-defibrillator 12 response to the operation.

A digital output from the monitor-defibrillator data storage/processor is provided to

control the activation of the battery test load. Activation of the load places a high current

demand on the monitor-defibrillator battery 18. This determines if the monitor-defibrillator

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battery pack contains any defective cells. The monitor-defibrillator 12 can determine the available device operation time (prior to recharging the battery) utilizing adjustments for abnormally high current draw, normal current draw, device fault conditions, and depletion of battery capacity during periods when the device is not in use.

Upon command from the patient base station or the monitor-defibrillator display, the monitor-defibrillator 12 performs a battery load test. The monitor-defibrillator 12 returns a pass-fail indication to the patient base station or the display. Load tests are most often performed with the display as the host. If the battery 18 fails the load test, the battery voltage measurement prior to the load test and at the point of failure are stored in the monitor-defibrillator non-volatile memory.

Referring to figure 3, the patient base station 30 provides circuitry in the charger interface module 34, that can charge or discharge the monitor-defibrillator 12 battery pack 18. The charger interface module 34 connects to the monitor-defibrillator 12 battery pack 18 via the PBS/M-D interface 32. Prior to battery pack 18 maintenance operations, the patient base station 30 will retrieve battery pack 18 identification information from the monitor-defibrillator 12 via the PBS/M-D interface 32.

Two charging modes are provided; rapid charging and float charging. During the rapid charge cycle the charger interface module 34 supplies charging current at the one hour charge rate of the battery pack 18. During float charge operations, the charger interface module 34 supplies charging current at the continuous maintenance rate of the battery pack 18.

The rapid and float charge current rates supplied by the charger interface module 34 are adjustable by the patient base station computer 40. The patient base station computer 40 will

configure the charger interface module 34 to supply a charge current rate that is appropriate for the connected battery pack 18.

During the discharge cycle, the charger interface module 34 provides a resistive load to the battery pack 18 that discharges the battery pack 18 at the one hour discharge rate of the battery pack 18. The discharge resistive load applied by the charger interface module 34 is adjustable by the patient base station computer 40. The patient base station computer 40 will configure the charger interface module 34 to apply a resistive load that causes a one hour current drain rate that is appropriate for the connected battery pack 18.

The battery charger interface module 34 can be controlled by the patient base station computer 40 or by the monitor-defibrillator 12 via the PBS/M-D interface 32. Monitor-defibrillator 12 control of the charger interface module 34 is accomplished by activating I/O control lines located in the PBS/M-D interface 32. These I/O lines will configure the charger interface module 34 for the desired charge/discharge operation. Alternately, the patient base station computer 40 can control the I/O lines and configure the charger interface module 34 for the desired charge/discharge operation. Under normal operation the monitor-defibrillator 12 controls the configuration of the charger interface module 34. The patient base station 30 configuration of the charger interface module 34 is a redundant feature that can be utilized if certain monitor-defibrillator 12 fault conditions exist such as a totally discharged monitor-defibrillator 12 battery pack 18.

Battery pack 18 charge and discharge cycles are initiated by the patient base station computer 40. When a monitor-defibrillator 12 is connected to the patient base station 30, the patient base station 30 retrieves monitor-defibrillator 12 battery operational status data from the data storage/processor 22 via PBS/M-D interface 32. The retrieved battery operational status

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data includes information such as the remaining battery capacity, fault condition flags, expiration parameters, battery maintenance parameters, and battery identification information. The patient base station 30 analyzes the retrieved battery data to determine the appropriate battery pack 18 maintenance procedure.

If the patient base station 30 determines that a rapid charge cycle is required, a command to initiate a rapid charge cycle will be sent to the monitor-defibrillator 12 via the PBS/M-D interface 32. Upon receipt of this command, the monitor-defibrillator 12 will configure the charger interface module 34 for rapid charge operation by activating I/O control lines located in the PBS/M-D interface 32. The monitor-defibrillator 12 will monitor the rapid charge sequence for completion and fault conditions. Successful rapid charge completion is determined by the monitor-defibrillator 12 monitoring the voltage level at the battery pack 18 positive terminal via the A/D converter located in the data storage/processor module 22. Successful rapid charge completion can also be declared if the monitor-defibrillator 12 detects a defined change in battery pack 18 temperature. The monitor-defibrillator 12 monitors the battery temperature via a temperature sensor located in the battery pack 18 and the A/D converter located in the data storage/processor module 22. When the monitor-defibrillator 12 detects a successful rapid charge completion, the monitor-defibrillator 12 will configure the charger interface module 34 for float charge operation by activating I/O control lines located in the PBS/M-D interface 32, reset the monitor-defibrillator 12 runtime parameter to the maximum value, and issue a rapid charge complete communications frame to the patient base station 30 via the PBS/M-D interface 32.

The rapid charge cycle will be aborted if the monitor-defibrillator 12 detects one of the following conditions: a battery pack 18 over voltage condition; a battery pack 18 over

temperature condition; or a defined time interval elapsed without a rapid charge completion detected. The limit values are manufacturing parameters that are stored in the monitor-defibrillator 12 data storage/processor module 22.

If the monitor-defibrillator 18 aborts the rapid charge cycle the following operations will be performed: the monitor-defibrillator 12 will configure the charger interface module 34 for float charge operation by activating I/O control lines located in the PBS/M-D interface 32; the monitor-defibrillator 12 will set it's runtime parameter to zero, which will cause patient warning messages on the display 24; and the monitor-defibrillator 12 will issue a rapid charge fault communications frame to the patient base station 30 via the PBS/M-D interface 32. If the patient base station 30 receives a rapid charge fault communications frame from the monitor-defibrillator 12, the following operations will be performed: the event will be logged in the patient base station 30 operations log file located in the data storage module 42; and the patient base station 30 will activate a patient warning message that indicates the monitor-defibrillator 12 should be serviced.

During the rapid charge cycle, the patient base station 30 will insure proper charge operation by monitoring various system parameters. The system parameter limit values are stored in the data storage module 42 during the patient base station 30 manufacturing process.

The charging current supplied to the battery pack 18 is monitored for proper levels via an A/D converter 64 (Figure 5) channel connected to the charger interface module 34. If the measured current is outside the defined limits, the patient base station 30 will abort the rapid charge cycle.

The charging voltage on the battery pack 18 is monitored for proper levels via an A/D converter 64 channel connected to the charger interface module 34. If the measured voltage is outside the defined limits, the patient base station 30 will abort the rapid charge cycle.

The patient base station 30 will abort the rapid charge cycle if the counter timer 72 (Figure 2) indicates the charge cycle exceeded the maximum charge completion interval.

If the patient base station 30 determines that a rapid charge cycle abort is required, the following operations will be performed: an abort rapid charge cycle command will be issued to the monitor-defibrillator 12 via the PBS/M-D interface 32; the patient base station 30 will configure the charger interface module 34 for float charge operation; the patient base station 30 will issue a command to the monitor-defibrillator 12 to set the runtime parameter to zero, which will cause patient warning messages on the display 24; the event will be logged in the patient base station 30 operations log file located in the data storage module 42; and the patient base station 30 will activate a patient warning message that indicates the monitor-defibrillator 12 should be serviced.

The patient base station 30 may initiate a discharge cycle of the monitor-defibrillator 12 battery pack 18. The discharge cycle is utilized both during the battery capacity test as well as during the process of reconditioning the battery energy storage capabilities.

If the patient base station 30 determines that a discharge cycle is required, a command to initiate a discharge cycle will be sent to the monitor-defibrillator 12 via the PBS/M-D interface 32. Upon receipt of this command the monitor-defibrillator 12 will set the monitor-defibrillator 12 runtime parameter to zero and configure the charger interface module 34 for discharge operation by activating I/O control lines located in the PBS/M-D interface 32. The monitor-defibrillator 12 will monitor the discharge sequence for completion and fault conditions.

Successful discharge completion is determined by the monitor-defibrillator 12 detecting the defined final discharge voltage threshold on the battery pack 18 positive terminal via the A/D converter located in the data storage/processor module 22. When the monitor-defibrillator 12 detects a successful discharge completion, the monitor-defibrillator 12 will configure the charger interface module 34 for float charge operation, by activating I/O control lines located in the PBS/M-D interface 32, and issue a discharge complete communications frame to the patient base station 30 via the PBS/M-D interface 32.

The discharge cycle will be aborted if the monitor-defibrillator 12 detects one of the following conditions: a battery pack 18 over temperature condition; or a defined time interval has elapsed without the detection of the discharge complete condition. The limit values are manufacturing parameters that are stored in the monitor-defibrillator 12 data storage/processor module 22.

If the monitor-defibrillator 12 aborts the discharge cycle the following operations will be performed: the monitor-defibrillator 12 will configure the charger interface module 34 for float charge operation by activating I/O control lines located in the PBS/M-D interface 32; and the monitor-defibrillator 12 will issue a discharge fault communications frame to the patient base station 30 via the PBS/M-D interface 32. If the patient base station 30 receives a discharge fault communications frame from the monitor-defibrillator 12, the event will be logged in the patient base station 30 operations log file located in the data storage module 42 and a patient warning message will be activated on the PBS display 47 that indicates the monitor-defibrillator 12 should be serviced.

During the discharge cycle, the patient base station 30 will insure proper discharge operation by monitoring various system parameters. The system parameter values are stored in the data storage module 42 during the patient base station 30 manufacturing process.

The discharge current drawn from the battery pack 18 is monitored for proper levels via an A/D converter 64 channel connected to the charger interface module 34. If the measured current is outside the defined limits, the patient base station 30 will abort the discharge cycle.

The discharge voltage on the battery pack 18 is monitored for proper levels via an A/D converter 64 channel connected to the charger interface module 34. If the measured voltage is outside the defined limits, the patient base station 30 will abort the discharge cycle.

The patient base station 30 will abort the discharge cycle if the counter timer 72 indicates the discharge cycle exceeded the maximum discharge completion interval.

If the patient base station 30 determines that a discharge cycle must be terminated, the following operations will be performed: an abort discharge cycle command will be issued to the monitor-defibrillator 12 via the PBS/M-D interface 32; the patient base station 30 will configure the charger interface module 34 for float charge operation; the patient base station 30 will issue a command to the monitor-defibrillator 12 to set the runtime parameter to zero, which will cause patient warning messages on the display 24; the event will be logged in the patient base station 30 operations log file located in the data storage module 42; and the patient base station 30 will activate a patient warning message that indicates the monitor-defibrillator 12 should be serviced.

The rapid charge cycle or discharge cycle will not be initiated if the monitor-defibrillator 12 determines that the battery pack 18 temperature is outside a set of defined limits. The limit values are manufacturing parameters that are stored in the monitor-defibrillator 12 data storage/processor module 22.

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If the monitor-defibrillator 12 is removed from the patient base station 30 prior to completion of all battery pack maintenance operations, a message and alarm will be activated on the patient interface module 46. The message will indicate the monitor-defibrillator maintenance is not complete and to return the monitor-defibrillator to the patient base station. The interrupted maintenance procedure will be continued if the removed monitor-defibrillator 12 is reconnected to the patient base station 30.

The energy delivery capabilities of the battery pack 18 are periodically verified by testing the battery 18 energy capacity and high current delivery capabilities. The patient base station 30 will perform an energy capacity test on the battery pack 18 if the elapsed time from the last capacity test, as indicated by data retrieved from monitor-defibrillator data storage/processor module 22 via the PBS/M-D interface 32, exceeds the maximum time interval parameter stored in the data storage module 42, or status data retrieved from monitor-defibrillator data storage/processor module 22 via the PBS/M-D interface 32, indicates that the battery 18 operational performance was deficient during the previous patient monitoring cycle.

The battery 18 energy capacity test procedure consists of the following operations: the patient base station 30 will activate a message on the patient interface 46 visual display 47 that indicates the monitor-defibrillator 12 is being tested and to wait for the test to complete; the patient base station 30 initiates a battery discharge cycle to condition the battery for a full charge cycle; initiate a rapid charge cycle when the discharge cycle is complete to charge the battery 18 to full capacity; the patient base station 30 initiates a second discharge cycle when the rapid charge cycle is complete; and the patient base station 30 initiates a final rapid charge cycle at the completion of the second discharge cycle to ready the battery 18 for service. The duration of the second discharge cycle is timed by a counter timer located in the monitor-defibrillator 12 data

storage/processor module 22. At the completion of the second discharge cycle the monitor-defibrillator 12 will compare the measured battery 18 discharge time with an acceptance parameter stored in storage/processor module 22. If the capacity discharge time is within the acceptable limit, monitor-defibrillator 12 will issue a capacity discharge pass communications frame to the patient base station 30 via the PBS/M-D interface 32.

If the capacity discharge time is not within the acceptable limit, the monitor-defibrillator 12 will set a battery capacity fault status flag located in the data storage/processor module 22, and issue a capacity discharge fault communications frame to the patient base station 30 via the PBS/M-D interface 32. The patient base station 30 will log the event in a log file located in the data storage module 42. Whenever the patient base station 30 receives a capacity discharge fault indication from the monitor-defibrillator 12, a patient warning message will be activated which indicates that the monitor-defibrillator 12 should be serviced as soon as possible. Each time a monitor-defibrillator 12 is connected to the patient base station 30, the patient base station 30 will retrieve the monitor-defibrillator 12 battery capacity fault status flag located in the data storage/processor module 22. If the battery capacity fault status flag is active, the patient base station 30 will initiate normal battery maintenance operations, with the exception of the battery capacity test which will no longer be performed. The patient base station 30 will also issue a command to the monitor-defibrillator 12 to set the runtime parameter to zero. This will cause repeated patient warning messages on the patient display 24.

If the battery status information indicates that the expiration date of the battery 18 has been exceeded (status information is entered during the initial configuration programming) or if the maximum number of charge cycles has been exceeded, the patient will be notified by the patient base station 30 that the monitor-defibrillator 12 should be serviced. The notification

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sequence will be activated until the patient acknowledges receipt by pressing a button 57 (Figure 4) on the patient interface 46, or the monitor-defibrillator 12 is removed from the patient base station 30. Normal battery maintenance will continue so that the patient may use the monitor-defibrillator 12.

When a rapid charge cycle or battery discharge cycle is initiated, the patient base station 30 will deactivate the particular one of the battery status LED indicators 51 which is the "READY" LED indicator on the patient interface module 46 and activate the particular one of the battery status LED indicators 51 which is the "CHARGING" LED indicator. During the rapid charge cycle, the patient base station 30 displays a message on the patient interface visual display 47 that the monitor-defibrillator battery 18 is being charged and the monitor-defibrillator 12 is not ready for use.

If monitor-defibrillator maintenance operations are complete at the conclusion of a successful rapid charge cycle, the patient base station performs the following:

A message is displayed on the PBS display 47 indicating that the monitor-defibrillator 12 is ready for use; the PBS 30 "READY" LED 51 is activated; the "CHARGING" LED 51 is deactivated; and the monitor-defibrillator 12 is powered down.

The patient base station 30 logs the following battery maintenance information into a maintenance log: the start and completion times of battery operations; the length of the charge/discharge cycles; any abnormal conditions; and the charge cycle count, and if enabled, the battery voltage measurements taken during charge and discharge cycles. The maintenance log is stored in the data storage module 42.

The patient base station 30 issues various diagnostic test commands to the monitor-defibrillator 12. These tests are performed on a regular basis. Some tests are performed

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each time the monitor-defibrillator 12 is connected to the patient base station 30. Others are performed only as required. The monitor-defibrillator 12 executes the received commands and reports the test results to the patient base station 30. The patient base station 30 maintains a log of the test results on the mass storage media 42. If a fault is detected during any diagnostic procedure, the patient is notified of the condition along with the appropriate corrective action.

Variations of the preferred embodiment are possible. For example, the preferred patient base station system utilizes a charger interface module board. Stacked on top of that board are purchased assemblies of PC104 boards which form the CPU module 40 and Ethernet module 52. These boards are ISA compatible because the expansion bus 54 is an ISA type bus. The stacks of PC104 boards require a great deal of cabling which is very costly. Thus, all of the major system functions could be implemented on a single PC board. This would eliminate much of the cabling.

In accordance with the patent statutes we have described principles of operation and preferred embodiments of our invention. It should be understood, however, that within the scope of the appended claims, the invention may be practiced in a manner other than as illustrated and described.

What is claimed is:

1.   A battery management system for a portable patient worn electronic energy

delivery device for monitoring and administering therapy for a treatable heart condition, the

battery management system comprising:

a.   a portable electronic device having a rechargeable battery means and a data

storage/processor means; and

b.   a base station having receptacle means for receiving the portable electronic

device, said receptacle means further comprising port means for operatively connecting the base

station with the portable electronic device so as to transfer data there-between, power supply

means for providing a current to said rechargeable battery means through said port means,

computer means adapted to exchange information with said data storage means and maintenance

means for providing an indication of the operation of the portable electronic device.

2.   The battery management system as recited in claim 1, wherein said maintenance

means comprises means for determining a charging condition of said rechargeable battery means,

means for comparing the charging condition with at least one predetermined parameter stored in

a data storage means operatively connected to said computer means, and means for inducing said

power supply means to provide a charging current to said rechargeable battery means when the

comparing means has determined the charging condition is below a predetermined level of the at

least one predetermined parameter.

3.   The battery management system as recited in claim 1, wherein said portable

electronic device comprises a monitor-defibrillator unit adapted to be worn by a patient for

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delivering electrical therapy to the heart of the patient upon the occurrence of a treatable heart arrhythmia, and said data storage means includes means for storing patient physiological data.

4. The battery management system as recited in claim 3, further comprising programming means and said base station comprises a programming interface, wherein said programming means permits an operator to input patient background data to said data storage means of the monitor-defibrillator unit.

5. The battery management system as recited in claim 4, wherein said programming means further comprises means for retrieving said patient physiological data from said monitor-defibrillator and for transmitting said patient physiological data to a remote location.

6. The battery management system as recited in claim 1, wherein said portable electronic device further comprises means for retrieving data from data storage means, and means for transmitting said data to a remote location.

7. The battery management system as recited in claim 1, wherein said data storage means comprises means for storing manufacturing data for the portable electronic device, said manufacturing data including at least one of the following:

a. device serial number;

b. rechargeable battery means serial number;

c. rechargeable battery means expiration date; and

d. a permissible number of rechargeable battery means recharges.

8. The battery management system as recited in claim 7, wherein said computer means further comprises a real time clock for providing an indication of actual date and time and means for comparing said actual date and time with said rechargeable battery means expiration date, and means for providing an alarm if said actual date and time exceeds said rechargeable battery means expiration date.

9. The battery management system as recited in claim 2, wherein said base station further comprises means for testing the operation of said rechargeable battery means, said testing means comprising means for discharging the rechargeable battery means to a predetermined starting level, means for recharging the battery to a predetermined charging level, means for performing a load test on said rechargeable battery means to determine integrity of said rechargeable battery means.

10. The battery management system as recited in claim 7, wherein said computer means further comprises counter means for counting the number of times said power supply means provides current to said rechargeable battery means, means for comparing said permissible number of rechargeable battery means recharges with the number of times counted by said counter means, and means for providing a second alarm if the number of times counted by said counter means is equal to said permissible number of rechargeable battery recharges.

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11.   The battery management system as recited in claim 8, wherein said base station further comprises a back-up power source operatively associated with said real time clock independent of said power supply means.

12.   The battery management system as recited in claim 1, said base station further comprising display means operatively associated with said maintenance means for displaying information indicative of the operation of the portable electronic device.

13.   The battery management system as recited in claim 12, wherein said display means comprises one or more of a character display panel and LED indicators for displaying the charging condition of said rechargeable battery means.

14.   A method of testing an operating characteristic of a portable patient worn electronic energy delivery device, said method comprising the steps of:

a.   providing a base station for receiving the portable electronic device, the base station having port means for transferring data between the base station and the portable electronic device;

b.   connecting the portable electronic device to said port means;

c.   transferring data from the portable electronic device to said base station;

d.   analyzing said data received from the portable electronic device; and

e.   providing an indication of the condition of the operating characteristic of the portable electronic device.

15. The battery management system as recited in claim 1 wherein said personal electronic device further comprises:

a. data processing means for determining available device operating time before said rechargeable battery means requires recharging, said data processing means operatively associated with said data storage means;

b. said data storage means stores data corresponding to at least one of abnormally high current draw, normal current draw during an elapsed time period, device fault conditions and depletion of battery capacity during non-use, and said data processing means utilizes said data in determining said available device operating time;

c. patient display means operatively associated with said data processing means for displaying said available device operating time; and

d. alarm means associated with at least one of said data processing means and said patient display means, said alarm means notifying a patient of said available device operating time.

16. The battery management system as recited in claim 1 wherein said personal electronic device further comprises:

a. voltage converter means for storing energy from said rechargeable battery means; and

b. control means operatively associated with said voltage converter means and said rechargeable battery means, said control means having:

i.   means for determining an energy condition of said voltage converter, said

energy condition including at least an insufficient energy condition wherein there is insufficient

energy to both deliver a treatment to the patient and preserve operating data,

ii.   means for determining a voltage condition of said rechargeable battery

means, said voltage condition including at least an inadequate voltage condition wherein the

battery capacity is inadequate for reliable operation of the device,

iii.   means responsive to at least one of said inadequate voltage condition and

said insufficient energy condition for one of operating said voltage converter means in a low

current mode and terminating the operation of said voltage converter means, and

iv.   discharge means responsive to said inadequate energy condition for

discharging said voltage converter means;

and

c.   notifying means operatively associated with said control means, said notifying

means informing the patient whether the personal electronic device can provide treatment based

on said converter energy condition and said voltage condition, and wherein said notifying means

is at least one of a means for providing an alarm, a means for providing a voice message, and a

personal electronic device display means.

17.   The battery management system as recited in claim 1 wherein said personal electronic device further comprises:

a.   control means operatively associated with said rechargeable battery means and said control means operating the personal electronic device in a low current mode when the device is not performing necessary system operating functions;

b.   said control means further having a means for determining a voltage condition of said rechargeable battery means, said voltage condition including at least an inadequate voltage condition wherein the battery capacity is inadequate for reliable operation of the device and wherein said control means refusing to power up the personal electronic device responsive to said inadequate voltage condition; and

c.   a digital to analog converter operatively associated with said control means and said control means can power down said analog to digital converter to conserve energy when not in use.

18.   The battery management system as recited in claim 1 wherein said personal electronic device further comprises:

a.   voltage converter means for storing energy from said rechargeable battery means;

b.   control means operatively associated with said voltage converter means and said rechargeable battery means and said control means having:

i.   means for determining an energy condition of said voltage converter,

ii.   means for determining a voltage condition of said rechargeable battery means, and

iii.   means for performing a load test on said rechargeable battery means for

testing high current capability of said rechargeable battery means;

and

c.   an analog to digital converter operatively associated with said control means and

said analog to digital converter for use in monitoring stored battery energy.

19.   The battery management system as recited in claim 1 wherein said data storage

means further comprises data processing means for determining available device operating time

before said rechargeable battery means requires recharging.

20.   The battery management system as recited in claim 19 further comprising portable

electronic device display means operatively associated with said data processing means, said

portable electronic device display means for displaying said available device operating time.

21.   The battery management system as recited in claim 19 wherein data

corresponding to at least one of abnormally high current draw, normal current draw during an

elapsed time period, device fault conditions, and depletion of battery capacity during non-use is

stored by said data storage means, and wherein said means for determining said available device

operating time uses said data.

22.   The battery management system as recited in claim 19 wherein said data

processing means further comprises an analog to digital converter.

23. The battery management system as recited in claim 22 wherein said analog to digital converter can be powered down to conserve power when not being used.

24. The battery management system as recited in claim 22 wherein said portable electronic device further comprises:

    a.   control means operatively associated with said rechargeable battery means; and

    b.   voltage converter means for storing energy from said rechargeable battery means.

25. The battery management system as recited in claim 24 wherein said control means comprises:

    a.   means for determining a converter energy condition of said voltage converter, said converter energy condition including at least an insufficient energy condition wherein there is insufficient energy to both deliver a treatment to the patient and preserve operating data;

    b.   means for determining a battery voltage condition of said rechargeable battery means, said battery voltage condition including at least an inadequate voltage condition wherein the battery capacity is inadequate for reliable operation of the device;

    c.   means responsive to at least one of said inadequate voltage condition and said insufficient energy condition for one of operating said voltage converter means in a low current mode and terminating operation of said voltage converter means; and

    d.   discharge means responsive to said insufficient energy condition for discharging said voltage converter means.

26. The battery management system as recited in claim 25 further comprising notifying means operatively associated with said control means for notifying the patient whether the personal electronic device can provide sufficient energy for treatment based on said converter energy condition and said battery voltage condition.

27. The battery management system as recited in claim 26 wherein said means for notifying is at least one of a means for providing an alarm, a means for providing a voice message, and said personal electronic device display means.

28. The battery management system as recited in claim 25 wherein said control means further comprises an analog to digital converter for monitoring stored battery energy.

29. The battery management system as recited in claim 25 wherein said control means further comprises means for performing a load test on said rechargeable battery means for testing high current capability of said rechargeable battery means.

ABSTRACT

A battery management system preferably has a base station utilized in connection with a portable electronic device for providing electrical therapy to the body of a patient in response to the occurrence of a treatable condition. The portable device can have a rechargeable battery, memory, data processor for determining available operating time for the portable device prior to recharging, and a display panel, or alarm, to inform the patient of such available operating time. The portable device data processor contains an analog to digital converter which is used to obtain and record data regarding the patient, the battery, and the portable device operational status. The base station can have a receptacle to receive the portable device, including a port for transferring data between the memory of the portable device and the base station, a power supply associated with the port for supplying charging current to the battery, a computer for exchanging information with the portable device memory, and a battery maintenance portion. The maintenance portion can perform tests on the battery to evaluate the condition thereof. The base station can further include a display and alarms to inform the patient regarding the condition of both the battery and the portable device. The portable device can also include a converter-defibrillator and a second battery maintenance portion which can operate independently of the base station. Tests can be performed, during operation of the portable device, to evaluate the condition of the battery while the portable device is separated from the base station.
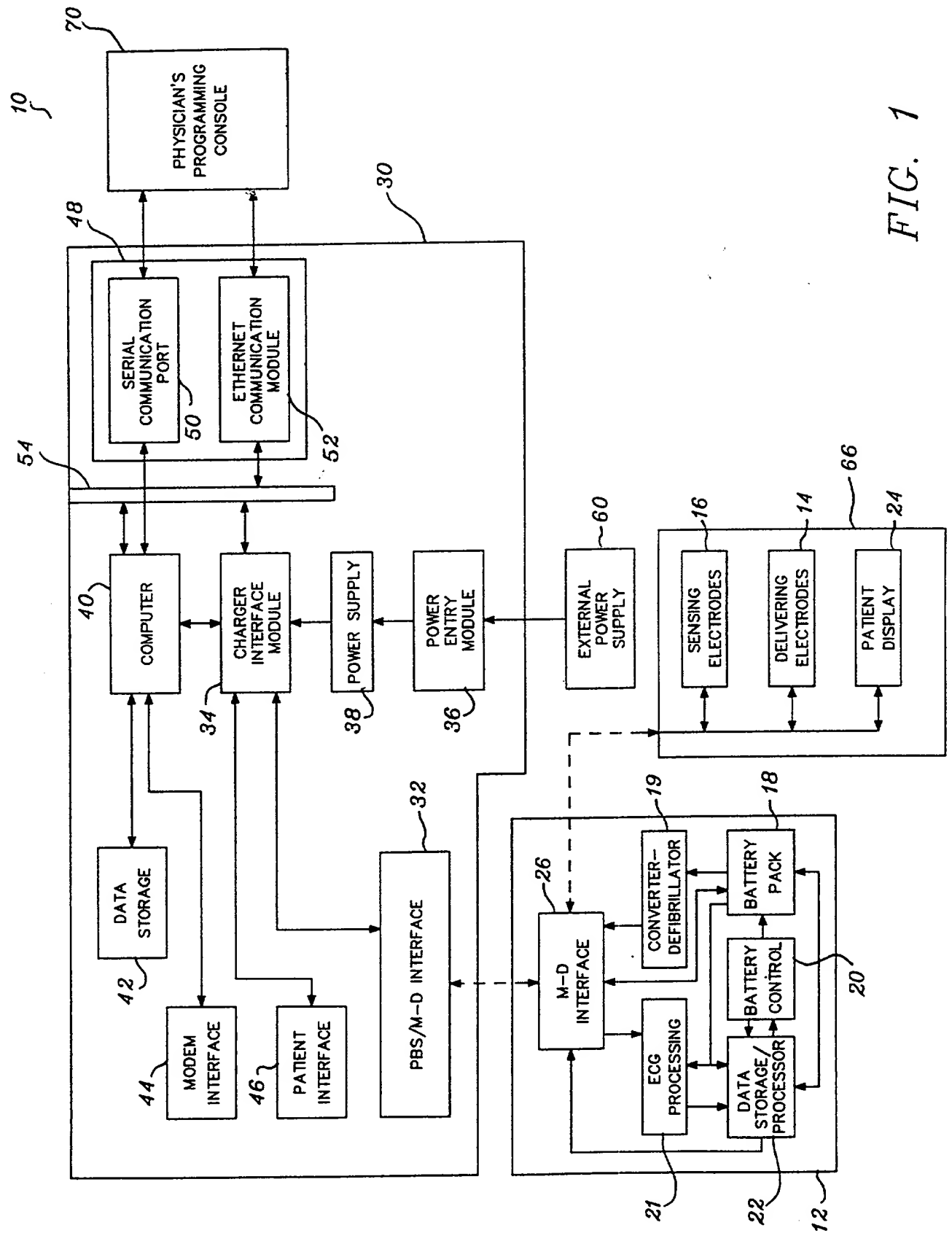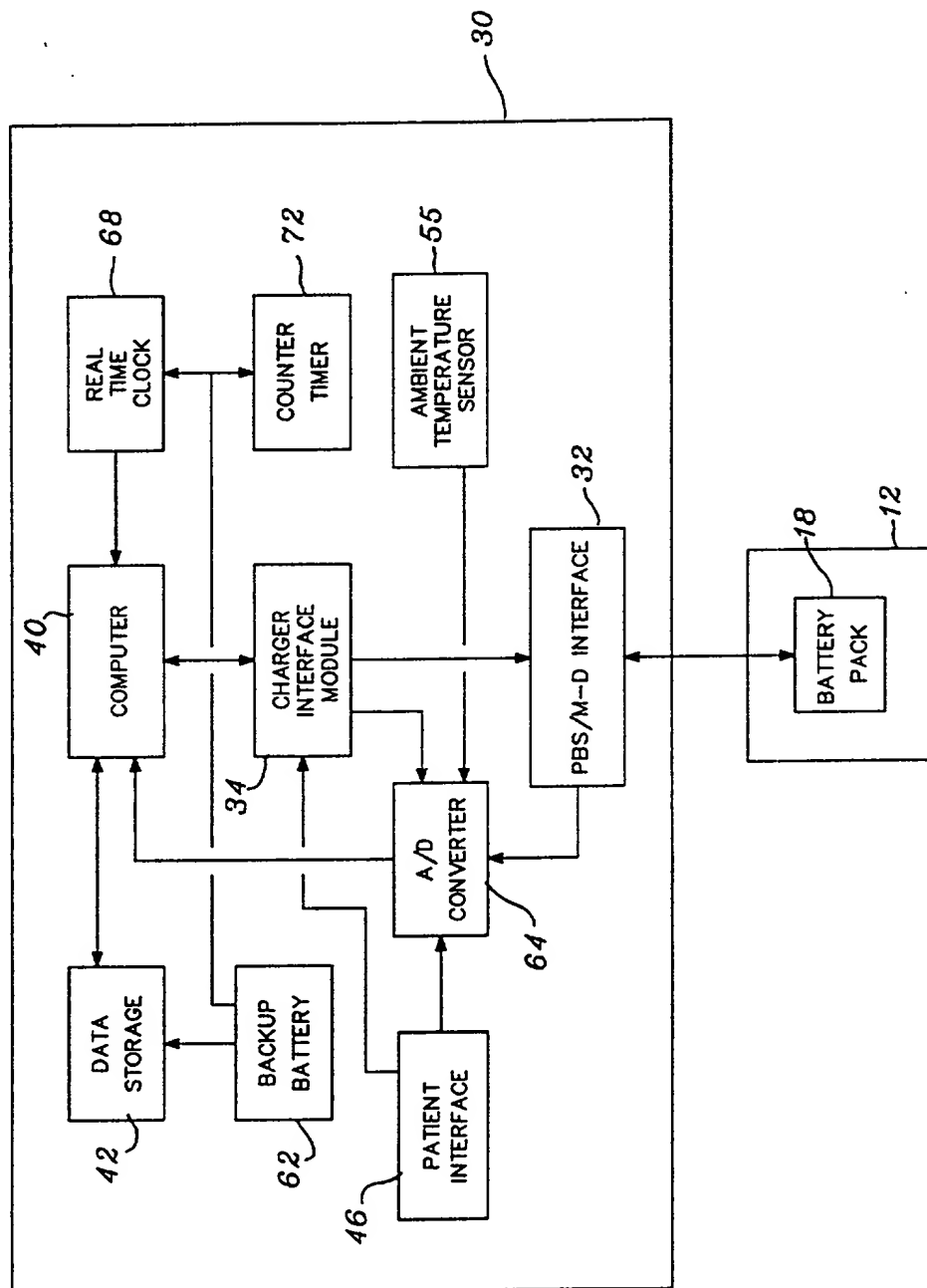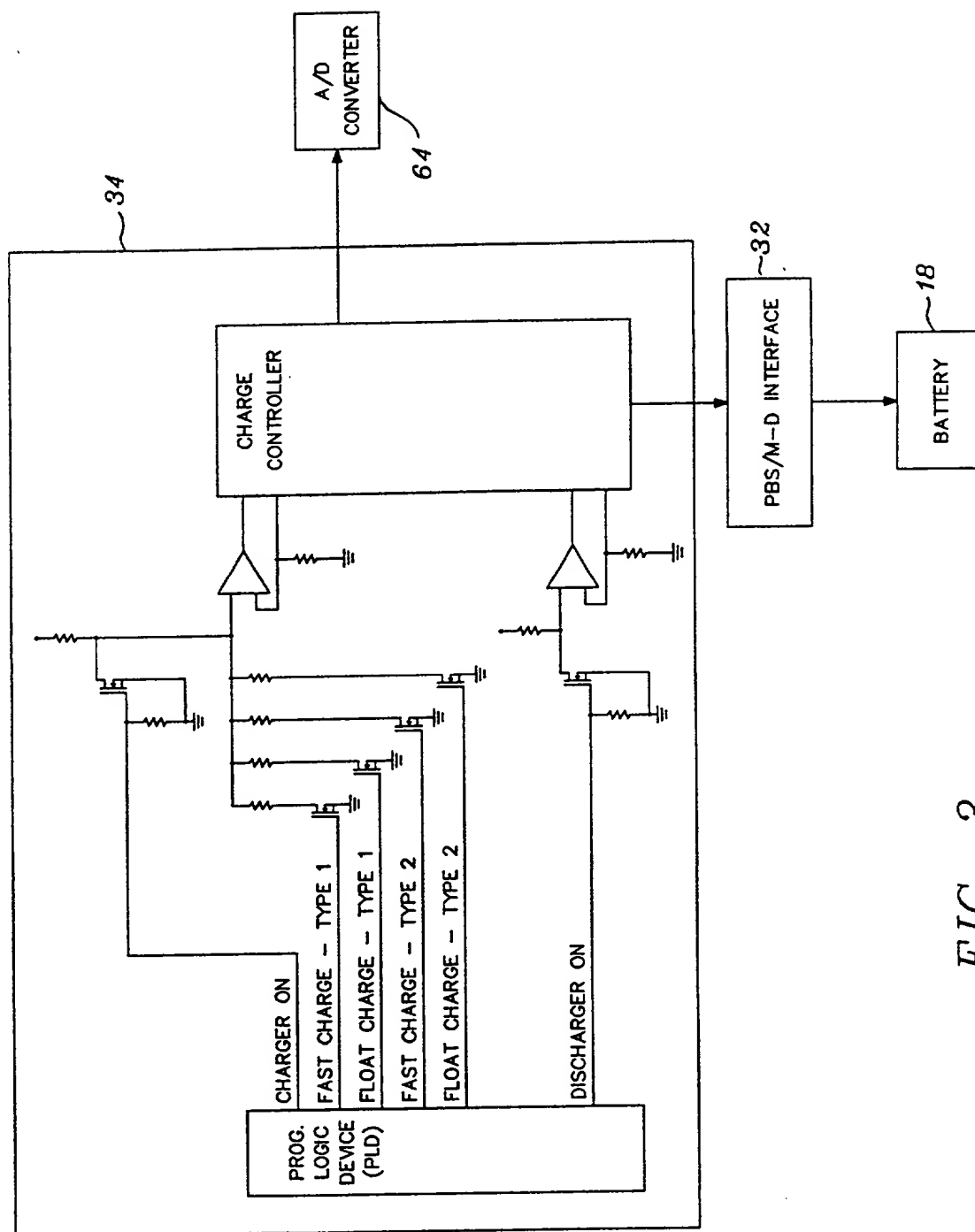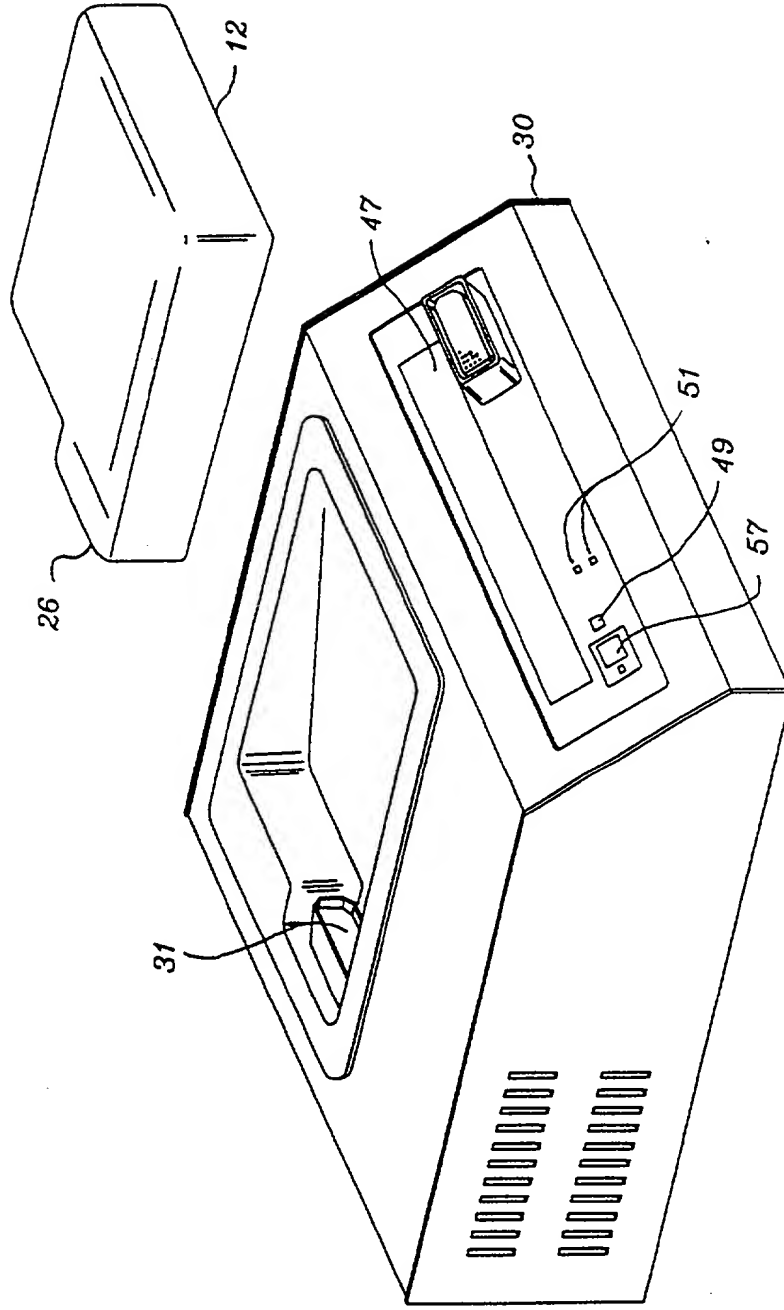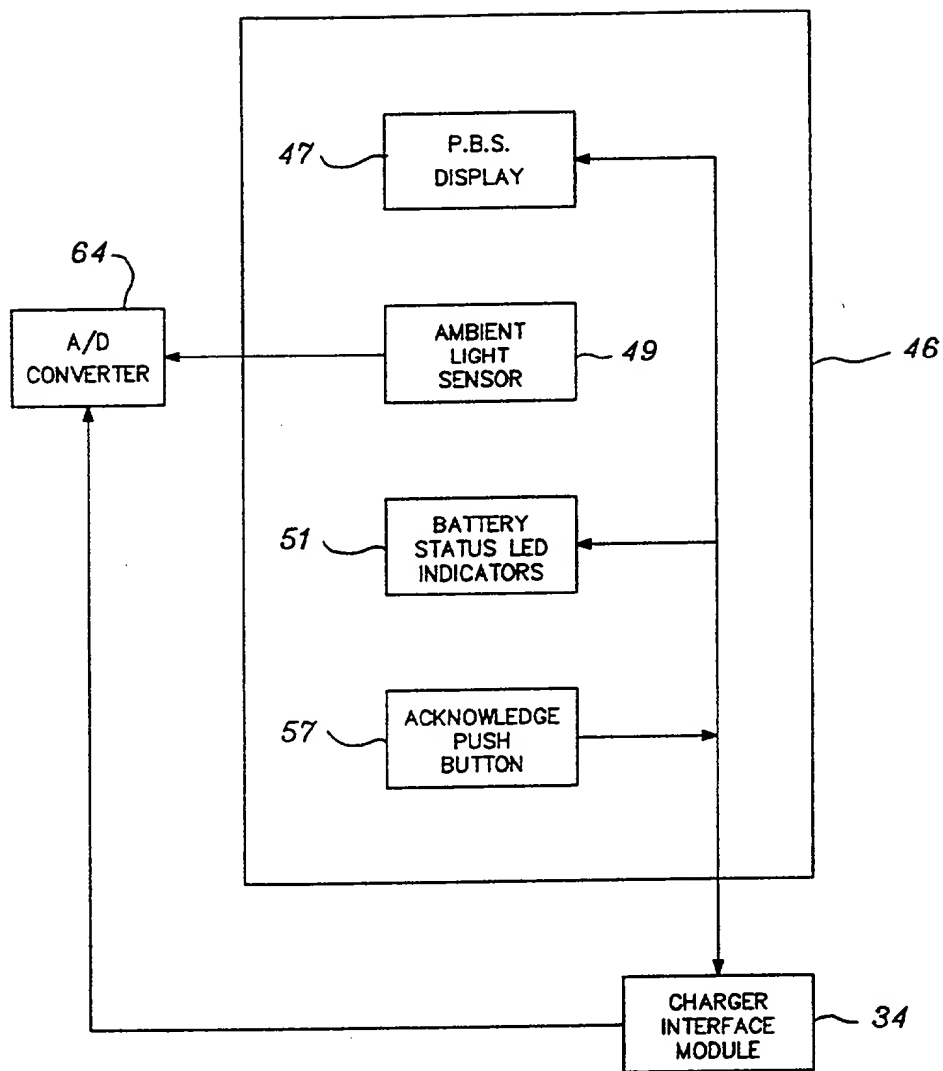
FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5

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For BATTERY MANAGEMENT APPARATUS FOR PORTABLE ELECTRONIC DEVICES

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) and 1.27(c)) - SMALL BUSINESS CONCERN

I hereby declare that I am

[ ] the owner of the small business concern identified below:

[X] an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN Lifecor, Inc.

ADDRESS OF CONCERN 121 Freeport Road

_____ Pittsburgh, Pennsylvania 15238

I hereby declare that the above identified small business concern qualified as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention, entitled BATTERY MANAGMENT APPARATUS FOR PORTABLE ELECTRONIC DEVICES _____ by inventor(s) _____

_____ Thomas E. Kaib, Edward J. Donnelly and Norman J. Connors

described in

[X] the specification filed herewith

[ ] application serial no. _____, filed _____

[ ] patent no. _____, issued _____

If the rights held by the above-identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who could not qualify as a small business concern under 37 CFR 1.9(d) or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e). *Note: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

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NAME _____

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I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

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NAME OF PERSON SIGNING _Larry D. Bowling_

TITLE OF PERSON OTHER THAN OWNER _President_

ADDRESS OF PERSON SIGNING _121 Freeport Road_

_____ Pittsburgh, Pennsylvania 15238

SIGNATURE _[signature]_   DATE